Cement concrete pavements technology at construction of main roads in Uzbekistan conditions

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Abstract. Uzbekistan’s road specialists have begun implementing a number of technological solutions in the construction and maintenance of roads. One of the most interesting innovations is the use of pavements and bases of main roads with compacted cement concrete. Such pavements are much stronger and more durable than existing. At construction of highways and main roads of international importance using of compacted cement concrete for which fall on loads from “cargo traffic”, will significantly prolong their durability and reduce time spending on laying. At present for the start of using of modern technology pilot tests are carried out and necessary guidelines have developed and these results presented in this issue.

1 Introduction

The Republic of Uzbekistan due to its favorable geographical location in the heart of the Central Asian region has always been a bridge between East and West. About 20 international transport routes to Russia, European Union, Caucasus, Afghanistan, Pakistan, Iran, Turkey and China pass through the territory of the republic. Today, the task is set to dynamically develop the transport infrastructure and road construction of the country, which should give an innovative, social and ecological vector for development of entire transport sector. It is considered that scientific approach, as well as corresponding regulatory and legal support of innovative development of road sector will allow increasing the efficiency of resources directed to road construction and improving quality of transport services.

In modern conditions, the problem of increasing the service life of road pavements are getting greater importance, since an actual level of their road-service quality in many ways determines the efficiency of the operation in time of entire network of public roads and, first of all, the main roads, as the most loaded with movement of vehicles.

At present, the total length of network of highways of the Republic of Uzbekistan is more than 183 thousand kilometers. Of these, more than 42 thousand kilometers are public roads, which are divided into roads of international, republican and local (regional)

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importance (Figure 1). The roads consist of 5 categories. (Figure 2). Through the territory of Uzbekistan are passed 20 international transport routes and destinations.

Fig. 1. Uzbekistan public road network

Fig. 2. Distribution of public roads by category

On types of road surfacing 21761 km (51%) are covered with asphalt concrete roads, 18008 km (42%) occupy a black surface, 1510 km (4%) falls on gravel, 928 km (2%) - ground and 350 km (less than 1%) - roads with cement concrete pavement (Figure 3).

Fig. 3. Distribution of public roads by types of pavements

In the process of reconstruction of federal roads there are real opportunities to significantly increase the working capacity of road pavements by using more progressive constructive and technological solutions and to obtain an economic effect comparable in magnitude with the total cost of reconstruction of highways [1-3] and tunnels also [4].

In accordance with the current target program, international norms and modern requirements, it is expected that in the next few years the construction and reconstruction of main roads will be 2306 kilometres in length, including 1410 kilometres of roads will be four-lanes (of which 474 kilometres with cement concrete pavements).
The construction of roads with concrete covering in the Republic of Uzbekistan is continuously increasing, they become the main type of main roads.

Scientific thought does not stand still. There are technologies that allow building roads with an optimal road structure. One of them is strengthening or stabilizing the soil with the help of hydraulic and organic binders, as a result of which the roadbed is not deformed under heavy loads and lasts longer.

The technology of cold recycling allows you to repair the asphalt road with a special cement mixture with the addition of hydraulic binders. The use of this mixture makes it possible to make a good concrete base, on which is laid asphalt concrete or cement concrete surfacing. It should be noted that this year Uzbekistan's road enterprises have begun to introduce a number of new technological solutions in the sphere of construction and operation of roads.

Among them, in particular, is the use of roller compacted cement concrete for the bases and pavements of roads. All the norms and standards necessary for the application of this technology were developed in the recent past [5-10].

2 Analysis of the feasibility of construction of asphalt concrete and cement-concrete roads

In Uzbekistan, cement-concrete roads were built before the 1980-s. Then the volume of cement production decreased, a wide production of bitumen began, which is used as an astringent for asphalt. A strategic decision was made to build asphalt roads. Now the situation changes in the opposite direction: bitumens become more expensive, and cement becomes more accessible [12]. Concrete roads today are built in countries with very different climatic conditions.

So, in the USA up to 60% of all federal routes are made with the use of cement concrete. Concrete roads are actively built in Canada, Austria, Belgium and Germany, as well as our closest neighbors - in Tajikistan and Kazakhstan [12].

The cost of construction of concrete roads can be 30% higher than asphalt concrete, or, under certain conditions, 5% lower. But all over the world evaluate the life cycle of roads, and here the total costs for the construction and maintenance of concrete roads are reduced by 40-50%. And the life cycle of concrete roads is three times longer than the life of asphalt concrete. They serve up to 50 years.

On figures 4 and 5 are shown schematic cross-section of asphalt-concrete and cement-concrete pavements on crushed stone.

Cement-concrete pavement is resistant to deformation (formation of rut and waviness) due to its higher strength. This, in turn, contributes to a lower (by 15-20% less) fuel consumption vehicles. This factor is also positive from the point of view of protecting the environment from car wastes that pollute it.

In addition to saving money, saving natural resources is very important, since asphalt (bitumen) is produced from processed oil, the reserves of which are rapidly drying up. Concrete is made from a material more accessible to man - limestone. Movement on cement concrete cover during rain or snowfall is safer than on asphalt concrete.

In rainy weather, irregularities and potholes in the asphalt are filled with water, which creates an additional danger of aquaplaning. In winter, the water in the potholes turns into ice, which reduces the coefficient of adhesion between the rubber tire and the road. At the same time, water does not accumulate on a smooth cement-concrete pavement.
Table 1 shows the coefficients of sliding friction between rubber, asphalt and concrete in dry and wet conditions.

<table>
<thead>
<tr>
<th></th>
<th>Rubber</th>
<th>Dry asphalt</th>
<th>Wet asphalt</th>
<th>Rubber</th>
<th>Dry concrete</th>
<th>Wet concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>0.5</td>
<td>0.25</td>
<td>0.45</td>
<td>0.6</td>
<td>0.85</td>
<td>0.75</td>
</tr>
</tbody>
</table>

To redirect the technology of road construction in Uzbekistan, there are almost all. The country created colossal wealth even during the times of Soviet power: hundreds of factories for the production of concrete and cement have been built and are functioning; there are quarries of sand and rubble practically in all regions. Through the extensive partnership of Uzbekistan with the rest of the world, it is possible to actively adopt the experience of other, more developed countries in terms of road construction.

3 Peculiarities of construction of cement-concrete roads from roller (rigid) compacted concrete

In Uzbekistan, two main methods of cement concrete surface construction are used: construction with the help of special machines, equipment and construction with the help of small-scale mechanization. A combined method is possible, in which a special vehicle and small-scale mechanization means. According to the first technology, in the presence of a concrete-laying machine, the delivery of the mixture is performed by dump trucks.

The concrete mix is poured onto a prepared base of lean concrete. Depending on the configuration of the concrete-laying machine, the leveling of the mixture and its distribution along the width of the stacked strip is carried out by a carriage of a concrete
Paver or with a bucket of an excavator or a bulldozer blade. After that, the mixture is compacted with stacker vibrators.

In concrete pavements, longitudinal and transverse joints are cut, in order to ensure the formation of joints with acceptable parameters for opening gaps in the designed position relative to the axes of the roadway. This prevents cracking in the concrete pavement when it is heated in summer or cooled in winter.

To ensure that the concrete slabs obtained as a result of joint cutting work together, the metal rods are laid in the seams. The rod is placed on the concrete paver, but it can be done manually. The pavement is then smoothed out and roughness is applied to it to improve the cohesion between wheel and pavement.

After the end of these operations, a special film-forming composition is applied to prevent loss of moisture from the concrete during hardening, which can lead to its cracking. The last operations can be done without a stacker, manually. Depending on the configuration of the concrete paver, with its help it is possible to arrange a monolithic parapet fence or side stones.

Concrete laying by means of small-scale mechanization is much less productive, but it is widely used in complex areas with rough terrain, if necessary, broadening of the existing pavement, etc. This was practiced in the construction of rural roads. In this case, a screed and a traveling shuttering are necessary for laying concrete.

In this case, the mixture can be delivered in concrete lorry or dump trucks. After unloading on a specially prepared base, the mixture is compacted with a deep vibrator or by means of a screed. Smoothing of the surface of concrete, roughness and film-forming is done manually.

As a basis for any type of coverage in many countries around the world, "lean concrete" is used. For laying lean concrete, these both methods can be used, and in addition, there is a fairly cheap third method that allows you to abandon such troublesome technological operations as seam construction.

**Fig. 6. Cross-section of pavement with cement-concrete monolithic structure**

This is the way to roll concrete in the pavement with conventional smooth-roller rollers. The method has been approved for the construction of the bases of the roads of the Khorezm region and Karakalpakstan in Uzbekistan.

Lean concrete, laid according to this technology or the technology of laying ordinary cement concrete by a concrete-laying machine, can be used as a base for heavy cement concrete of road covering (Figure 6).

In industrialized countries (USA, Canada, Australia, Great Britain, Germany, Sweden, France, Norway, Spain and many others), the construction of road surfaces from rigid cement concrete mixes, which are compacted by rolling, is expanding.
Leading engineering companies constructing laying road machinery create powerful ramming bars for universal road laying machines and use them to create the foundations and coverings of the roadway and highways from rolled concrete, which are called "RCC-Pavements" in other countries [12].

Roller compacted concrete means rigid cement concrete transported by heavy-duty dump trucks or concrete mixers to the construction site, packed with powerful high-density boards of heavy-duty asphalt pavers and packed with various types of rollers. The rolled concrete was of great importance in the construction of dams and retaining walls of dams.

Many objects of this kind have been built all over the world, or they are still under construction. For the past few years, rigid-rolled concrete has been used extensively in the EU, USA and Canada. Having proved themselves in practice in these countries, this building material gradually "got" to Uzbekistan. It is very easy to identify concrete of this type - when it vibrates and rams on the desktop, only traces of water appear, while from ordinary concrete, water flows out with significant masses.

In addition, rigid concrete is characterized by low cement content, the possibility of using construction waste as a filler and using crushed stone as the main filler. In this case, we distinguish coarse-grained rigid concrete and fine-grained rigid concrete - a fraction of crushed stone up to 40 mm and up to 5 mm, respectively. These factors are both the main advantages and the main disadvantages of this material.

Along with the reduction in the cost of concrete (due to the smaller amount of cement and water), rigid concrete requires high energy costs for kneading, compaction and quality control. The rigid rolled concrete was used in the construction of bases and pavements for the two-stage construction of road (Figure 7). The South Korea POSCO Engineering & Construction Co., Ltd company completed the construction of 91 kilometers of a 4-lane road with cement-concrete pavement on the section 490-581 km of the A-380 Guzar-Bukhara-Nukus-Beineu s in Uzbekistan highway. The project of "Development of regional

Fig. 7. Construction of the carriageway of motor roads A380 Guzar-Bukhara-Nukus-Beineu in Uzbekistan
highways. Phase-1" was implemented with the participation of the Asian Development Bank (Final Environmental Monitoring Report, 2013 UZB: Loan No. 2403-UZB, CAREC Regional Road Project, Sections B2, B3 & B4, Annual Report October, 2013)

The use of rigid concrete is justified for cases when a building or a structure under the conditions of erection is subjected to a significant load immediately after its construction. In cases where we allow a long period of strength set, it is economically and technologically more feasible to use traditional "plastic" types of concrete mixtures.

In the event that for some reason between the rolling of rigid concrete and the arrangement of a "clean" pavement there is a significant time gap, the concrete must be protected from the evaporation by a polyethylene film or other traditional methods.

The laying of pavements on the base, made of rigid concrete is allowed immediately after its ramming. This allows you to "omit" (not to apply) measures for the care of concrete structures and products. It is allowed use of mineral additives as the additional savings in cement.

The experience of large-scale construction of A-380 road has revealed the need to improve the existing technology. In particular, it is required to increase the uniformity of concrete and improve its quality. Officials, laboratory assistants and workers during a month mastered a sufficiently large number of laboratory tests necessary to control the manufacture, transportation, packing and compaction of cement concrete in the pavement.

The concrete mixture was prepared in continuous mixer blades, transported in dump trucks and distributed with a layer with thickness of 270 mm onto a crushed stone base with thickness of 150 mm reinforced with cement. The mixture was compacted with a vibrating roller weighing 12 t per four passage. Film-forming material was used to care for the pavement. After 16 months of operation, the overall condition of the site pavement was good.

The figure 8 shows the recommended schemes of cement concrete pavements and bases of low-cement coagulated rigid concrete mixes [10]. The underlayer is arranged from natural sand, as well as partially or completely replaced by sand, obtained from the processing of cement and asphalt-concrete structures, which must meet the requirements of GOST 7473.

1 – cement concrete pavement of class B25 - B30; 2 - base of rolled concrete with partial or full replacement of crushed stone and sand with materials from processing of cement and asphalt-concrete structures; 3 - base of crushed stone, obtained from the processing of cement and asphalt-concrete structures; 4 - underlying layer of sand obtained from processing of cement and asphalt-concrete structures; 5 - polyethylene film, glassine

**Fig. 8.** Schematic diagrams of constructions of main roads with cement-concrete pavements and bases from low-cement coagulated rigid concrete mixes
The thickness of the sand layer is determined by the project taking into account the hydrological features of the adjacent territories and the type of road structure. A technological layer is arranged with thickness of 15 cm from compacted rubble of mark 400, sand-gravel mixture, soil cement or cement concrete of mark 1 (Table 2).

On the technological layer is laid the base of rolled low-cement concrete marks of 2, 3, 4, respectively. In the pavements for stage construction at the first stage, in accordance with the design, the base is made of concrete of classes for compressive strength B25; B22.5; B15. They serve as a cover for the construction period of the facility.

Table 2. Basic design characteristics rolled-low-cement concretes

<table>
<thead>
<tr>
<th>Mark of roller compacted concrete</th>
<th>Strength limit, (kg/cm²)</th>
<th>Purpose for compression for bending tension</th>
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<tbody>
<tr>
<td>1 (B5)</td>
<td>75</td>
<td>10</td>
</tr>
<tr>
<td>2 (B7,5)</td>
<td>100</td>
<td>16</td>
</tr>
<tr>
<td>3 (B15)</td>
<td>200</td>
<td>24</td>
</tr>
<tr>
<td>4 (B22,5; B25)</td>
<td>300</td>
<td>32</td>
</tr>
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</table>

In the second stage, after the completion of all general construction works, the construction of a pavement of monolithic concrete is carried with classes for compressive strength B30; B27.5; B25.

4 Conclusion

The paper gives information about using of modern cement concrete pavements at construction of main roads in republic of Uzbekistan. The construction of roads with concrete covering in the Republic of Uzbekistan is continuously increasing, they become the main type of main roads.

In future it lead to decreasing of risk for urban objects also [13].

Scientific thought does not stand still. There are technologies that allow building roads with an optimal road structure. One of them is strengthening or stabilizing the soil with the help of hydraulic and organic binders, as a result of which the readbed is not deformed under heavy loads and lasts longer. Analysis of the feasibility of construction of asphalt concrete and cement-concrete roads is showed the advantages of last type of pavements.

At construction of carriageway of motor roads A380 Guzar-Bukhara-Nukus-Beineu in Uzbekistan was used the technology of "RCC-Pavements". The experience realized by the project of "Development of regional highways. Phase-1" is allowed to create standards for design and construction of main and other type of roads with cement-concrete pavements and bases from low-cement coagulated rigid concrete mixes.

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